Reducing Prawn-trawl Bycatch in Australia: An Overview and an Example from Queensland

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Introduction

Australian prawn-trawl fisheries employ small-scale industrial fleets ranging from owner-operator vessels of 10 m in length to large company-based fleets with vessels up to 40 m in length. Fleet composition varies between fisheries. Otterboard trawling for prawns and scallops occurs in the coastal waters of most states of Australia (Fig. 1).

In Australia, bycatch is that part of the catch that is not kept for marketing but is returned to the sea for economic, legal, or personal reasons. It may include fish, crustaceans, mollusks, echinoderms, sponges, stingrays, sharks, and sea turtles. Bycatch varies spatially and seasonally in Australian prawn-trawl fisheries, with the ratio of bycatch to prawns generally being low (3.5:1) in temperate-water fisheries and high (15:1) in tropical-water fisheries (Dredge, 1988; Harris and Poiner, 1990; Andrew and Pepperell, 1992; Pender et al., 1992; Carrick, 1997). Many bycatch species could be of commercial value, but the remoteness of the fisheries, the high cost of freezing and storing the catch onboard, and the lack of organized markets for these species has led to high value-per-unit species becoming the retained catch.

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ABSTRACT —Prawn trawling occurs in most states of Australia in tropical, subtropical, and temperate waters. Bycatch occurs to some degree in all Australian trawl fisheries, and there is pressure to reduce the levels of trawl fishery bycatch. This paper gives a brief overview of the bycatch issues and technological solutions that have been evaluated or adopted in Australian prawn-trawl fisheries. Turtle excluder devices (TED's) and bycatch reduction devices (BRD's) are the principal solutions to bycatch in Australian prawn-trawl fisheries. This paper focuses on a major prawn-trawl fishery of northeastern Australia, and the results of commercial use of TED's and BRD's in the Queensland east coast trawl fishery are presented. New industry designs are described, and the status of TED and BRD adoption and regulation is summarized. The implementation of technological solutions to reduce fishery bycatch is assumed generally to assist prawn-trawl fisheries within Australia in achieving legislative requirements for minimal environmental impact and ecological sustainable development.

Australian Overview

Prawn-trawl fisheries within Australian waters are highly regulated compared with other countries, and all are limited-entry fisheries. Bycatch issues in northern Australian prawn-trawl fisheries focus predominantly on unwanted fish bycatch and the incidental capture and mortality of sea turtles in trawl nets (Table 1). Bycatch issues in southern Australian prawn-trawl fisheries focus predominantly on unwanted fish and crustacean bycatch (Table 1).

There are several reasons why bycatch issues in Australian prawn-trawl fisheries have received considerable attention over the past decade. Most Australian fisheries management agencies have a legislative mandate to ensure that trawl fisheries comply with the principles of ecological sustainable development (ESD), such as the Commonwealth "Fisheries Management Act 1991" and the Queensland "Fisheries Act 1994." Many Australian prawn-trawl fisheries also have legislation or policies that require a reduction in the take of nontarget species and a minimization of the impact of trawling on the ecosystem (Anonymous, 1998).

The drowning of sea turtles in trawl nets of northern Australia has been suggested to be the cause of the decline of the nesting population of loggerhead turtles, *Caretta caretta*, in eastern Australia (Limpus and Reimer, 1994). It is estimated that a combined total of about 11,000 sea turtles are caught annually in the northern prawn fishery and the Queensland east coast trawl fishery (Poiner et al., 1990; Robins, 1995; Poiner and Harris, 1996). Mortality rates of trawl caught turtles are estimated to be between 1% and 14%, depending on the duration of the tows associated with particular locations within these fisheries (Robins, 1995; Poiner and Harris, 1996). The main species of sea turtle caught in Australian prawn-trawl nets are flatback turtles, *Natator depressus;* loggerhead turtles; green turtles, *Chelonia mydas*; and olive ridley turtles, *Lepidochelys olivacea*. Of these, the loggerhead turtle is listed as endangered at both state and Commonwealth levels and is the focus of a national recovery plan (Anonymous, 1999). Furthermore, the Commonwealth "Endangered Species Protection Act 1992" and the nomination of trawling as a "key threatening process" has provided an additional means of pressuring the prawn trawling industries of northern Australia to mitigate their catch of endangered sea turtles.

The U.S. embargo of shrimp caught in nets without TED's created some additional pressure on Australian prawn fisheries to address their catch of sea turtles. However, most Australian prawn-trawl fisheries were not directly influenced by the U.S. embargo, because the majority

Table 1.—Bycatch issues within Australian prawn-trawl fisheries and the status of adoption of TED's and BRD's.

Fishery	Bycatch issues	Key initiators	Technological solutions
Queensland east coast[1]	Sea turtles and fish, since the late 1980's	Conservation driven but supported by industry	Mandatory TED's in 7 areas as of 1 May 1999; mandatory BRD's in daytime trawling by early 1999
Torres Strait	Sea turtles, unwanted fish bycatch	Conservation driven	Voluntary use and testing of TED's and BRD's
Northern Prawn	Sea turtles, unwanted fish bycatch since the late 1980's	Conservation driven but supported by industry	Compulsory use of TED's and BRD's 1 April 2000
Western Australia: Kimberley coast	Jellyfish	Industry driven	Voluntary use of grids
Western Australia: Exmouth Gulf	Fish, seaweed, and crabs since 1996	Industry driven	Voluntary grid and BRD trials
Western Australia: Shark Bay[1]	Sea turtles and crabs since 1996	Industry driven	TED and BRD research trials in progress
South Australia: Spencer Gulf and West Coast	Crabs and fish since the mid 1980's	Industry driven	Voluntary use of crab bags, mandatory areas closures, grid and BRD trials
South Australia: Gulf of St. Vincent	Small prawns and fish since 1995	Industry driven	Voluntary use of square-mesh codends at selected times
New South Wales: estuaries	Fish since late 1980's	Government driven, supported by industry	Voluntary use of BRD's (Nordmore grid) at selected times and places
New South Wales: oceanic	Fish since late 1980's	Government driven, supported by industry	Voluntary use of BRD's (square-mesh panels) at selected times and places

[1] Fisheries either entirely or partially within a "World Heritage Area."

of Australian prawn catch is exported to Asia (ABARE, 1998).

"World Heritage" status has brought increased scrutiny of commercial fishing practices, especially trawling operations, to ensure that the exploitation of fisheries resources do not occur at the expense of the quality of the ecosystem. Two Australian prawn-trawl fisheries occur within "World Heritage Areas," these being the Great Barrier Reef World Heritage Area in Queensland, and the Shark Bay World Heritage Area in Western Australia. World Heritage status implies that the listed area has fixed cultural and natural properties of such outstanding value, from a global perspective, that the site listed should be conserved and protected for the benefit of all humanity (Valentine et al., 1997).

Although the bycatch of unwanted fish has been an issue for a long time, pressure to reduce the capture of noncommercial species has increased recently. Reducing fishery bycatch had been addressed primarily through the use of technological gear solutions, such as turtle excluder devices (TED's) and bycatch reduction devices (BRD's). Additional ways to reduce the overall bycatch of prawn-trawl fisheries have been achieved through the reduction in the number of days fished or specifications of allowable fishing gears (i.e. smaller nets). Many TED's and BRD's are being used in various fisheries, depending on the reason for reducing bycatch and the type of bycatch within the fishery (Table 1). For example, square-mesh panels are voluntarily used during oceanic trawling in New South Wales for eastern king prawns, *Penaeus plejebus*, to allow the escape of unwanted fish bycatch (Broadhurst and Kennelly, 1997), while crab-bags and grids have been used in Spencer Gulf, South Australia, to remove blue swimmer crabs, *Portunus pelagicus*, from the catch (Carrick, 1997).

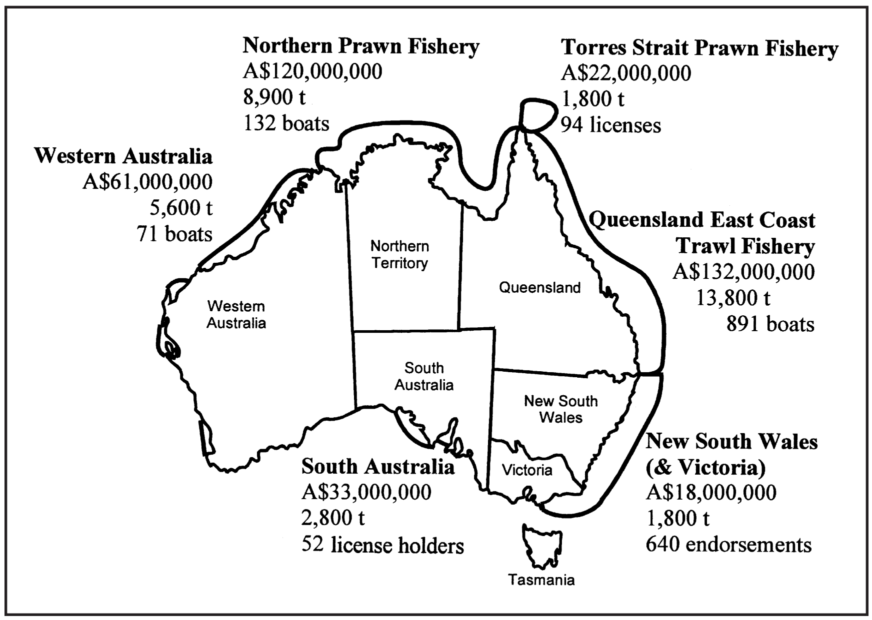

Figure 1.—Trawl fisheries of Australia for prawns and scallops (ABARE, 1998)

The Queensland east coast trawl fishery and the northern prawn fishery (Fig. 1) were the first Australian prawn-trawl fisheries to have legislative deadlines for the compulsory use of TED's and BRD's. In the Queensland east coast trawl fishery, TED's and BRD's are being phased-in over 2 years (Anonymous, 1998), and legislation supporting these requirements in the Queensland east coast trawl fishery was gazetted in April 1999. TED's were made compulsory on 1 May 1999 in seven areas where the risk to sea turtles of trawl capture and drowning is appreciable.

A multiple-agency risk assessment process has reviewed additional areas in which TED's may be needed. Likewise, BRD's were made compulsory as of 1 May 1999 during all daytime prawn trawling in the Queensland east coast trawl fishery. The next phase of BRD regulation involves all trawlers working within 9.26 km (5 n.mi.) of the Queensland east coast using BRD's. TED's and BRD's will be compulsory on all trawlers working within the northern prawn fishery from the commencement of fishing in 2000. This regulation was approved by the Australian Fisheries Management Authority in early 1999.

TED's and BRD's are loosely defined for the Queensland east coast trawl fishery, but are more prescriptively defined for the northern prawn fishery. The aim of TED and BRD definitions in both fisheries is to allow flexibility in design during the initial phase of compulsory use of TED's and BRD's. There is a need to ensure that the designs developed by the fishing industry are efficient and effectively meet the desired targets of a 95% reduction in sea turtle bycatch (Anonymous, 1999) and the reduction of unwanted fish bycatch (Anonymous, 1998; NORMAC, 1998). The compulsory use of bycatch reduction technology in these fisheries has received the support of the respective fishing industry associations and representative bodies. This has been achieved through a long-term, collaborative approach between government agencies and the commercial fishing industry to develop acceptable and practical solutions to reducing fishery bycatch.

It is difficult to generalize the history and adoption of bycatch reduction technology in Australian prawn-trawl fisheries, as each fishery has unique characteristics that have molded the process of gear development and adoption. We use the Queensland east coast trawl fishery as an example of an Australian prawn-trawl fishery where TED's and BRD's have been adopted.

Queensland East Coast Trawl Fishery

The Queensland east coast trawl fishery covers a large and diverse geographic area from lat. 10°30′S to 28°00′S, and includes areas of the continental shelf, major shallow-water embayments, and the Great Barrier Reef World Heritage Area. Between 85,000 and 95,000 boat-days of fishing effort are recorded each year (Williams, 1997). Landings are about 10,000 t, being valued at between A$120 and A$130 million per year (Williams, 1997). About 890 vessels are licensed to trawl on the Queensland east coast, most of which are owner/operators or small family companies. Commercial catch includes 12 species of penaeid prawn (Table 2), two species of scallop, *Amusium* spp., and one species of whiting, *Sillago robusta*. Also retained, but not usually targeted, are blue swimmer crabs, *P. pelagicus;* shovel-nosed lobsters, *Thenus* spp.; and squids, *Photololigo* spp. and *Sepioteuthis* spp.

Several bycatch issues are common throughout the Queensland east coast trawl fishery. Conflict is most prevalent when trawling occurs adjacent to population centers where recreational fishing is popular or when there is a conflict over resource allocation (i.e. blue swimmer crabs) between overlapping sectors of the commercial fishing industry. Concerns about impacts on benthic communities and habitat structure are common throughout the fishery, except for oceanic areas where the sea floor is predominantly sand. This is a particularly prominent issue in the Great Barrier Reef World Heritage Area, where public expectation and scrutiny of the fishery is high (Tanzer et al., 1997). Bycatch discarded from vessels trawling inshore can wash up on public beaches causing conflict between the local community and commercial fishermen. The capture of unwanted species and the subsequent "waste" of these animals is an issue common throughout the fishery, although the magnitude of the problem varies considerably between sectors. The incidental capture of protected species such as sea turtles and sea snakes is also an issue throughout the fishery, but again varies spatially in its extent.

Table 2.—Penaeid prawn species taken by the Queensland east coast otter trawl fishery.

Species	Common name
Penaeus plebejus	Eastern king prawn
Penaeus merguiensis	Banana prawn
Penaeus longistylus	Red spot king prawn
Penaeus latisulcatus	Blue-legged king prawn
Penaeus esculentus	Brown tiger prawn
Penaeus semisulcatus	Grooved tiger prawn
Penaeus monodon	Leader prawn, giant tiger prawn
Metapenaeus ensis	Red endeavour prawn
Metapenaeus endeavouri	Blue endeavour prawn
Metapenaeus macleayi	School prawn
Metapenaeus bennettae	Greasyback prawn
Trachypenaeus spp.	Hardback prawn

TED's and BRD's

Several research projects have evaluated TED's and BRD's in the Queensland east coast trawl fishery (Robins-Troeger, 1994; Mounsey et al., 1995; Robins-Troeger et al., 1995; McGilvray et al., 1998; Robins and McGilvray, 1998; Goeden[1]). These research trials suggested varying degrees of efficiency of the bycatch reduction technology (Table 3). However, the location of the trial and the associated quantity and composition of the bycatch was probably the most influential factor determining the efficiency of a particular device in a particular location (Robins and McGilvray, 1998). Research trials could never encompass the range of fishing locations and conditions in which the Queensland east coast trawl fishery operates.

Several industry members took an interest in developing devices to reduce fishery bycatch. The devices varied depending on the need of the particular fisherman. Some fishermen developed grids to exclude turtles, rays, sponges, and jellyfish, because these animals were caught frequently or because the value of their target catch could be increased markedly (e.g. the collection of live leader prawns as broodstock for the aquaculture industry).

Despite research trial success and the success of individuals, only a handful of the 900 or so vessels in the Queensland east coast trawl fishery had adopted TED's or BRD's by 1996. To promote and encourage the use of TED's and BRD's throughout trawl fisheries of northern Australia, a broad exten-

[1] Goeden, G. 1985. An evaluation of the trawl efficiency device in Queensland waters. Queensland Dep. Primary Ind. Internal Rep., 16 p.

Table 3.—Summary of bycatch reduction gear tests in the Queensland east coast.

Trial category	Gear	Fishery conditions[1]	No. of tows	Performance of TED's or BRD's vs. standard trawl nets: Prawn catch Mean	Prawn catch Range[2]	Bycatch Mean	Bycatch Range[2]	Comments
Research vessel, research trials	Morrison soft TED[3]	Subtropical, estuarine	20	–29%	–46% to – 7%	–32%	–46% to –14%	Tendency to clog with seaweed and crabs in estuarine areas
		Subtropical, estuarine	20	–18%	–31% to –2%	–2%	–21% to +21%	
		Subtropical, oceanic	23	–8%	–30% to +20%	–21%	–38% to –1%	
		Subtropical, oceanic	17	–19%	–33% to –5%	–13%	–34% to +2%	
Research vessel, research trials	AusTED[4]	Subtropical, estuarine	21	–9%	–32% to +20%	–18%	–32% to 0%	Tested in a limited number of areas, no problems with clogging encountered
		Subtropical, oceanic	27	–1%	–25% to +32%	–19%	–33% to –1%	
		Subtropical, oceanic	19	–2%	–26% to +30%	–12%	–27% to +7%	
		Subtropical, coastal	13	+3%	–57% to +149%	–55%	–68% to –36%	
Commercial vessel, research trials	AusTED II[5]	Subtropical, estuarine	40	–3%	–9% to +3%	–16%	–22% to –10%	Worked well in "clean" grounds, but tended to clog with sponges and starfish, leading to prawn losses
		Subtropical, oceanic	20	–9%	–16% to –2%	–15%	–27% to –2%	
		Tropical, coastal	8	–1%	–9% to +7%	–31%	–45% to –14%	
		Tropical, inter-reef	8	–36%	–46% to +23%	–49%	–56% to –40%	
Commercial vessels, supervised gear trial	Super shooter TED[6]	Tropical, inter-reef	12	–5%	–25% to +20%	No data	No data	Excludes turtles, stingrays, and sharks; can become clogged with starfish
		Tropical, coastal	15	+6%	–7% to +21%	0%	–18% to +21%	
Commercial vessels, supervised gear trial	Seymour TED[6]	Tropical, inter-reef	40	–3%	–13% to +8%	–15%	–24% to –5%	Clogging with large rocks, sponges, and starfish is only a problem in selected areas; frequent exclusion of sponges appears to be correlated with prawn loss; efficiently excluded large animals
Commercial vessel, research observer	Monofilament BRD[6]	Daytime, coastal	35	0%	–36% to +55%	–39%	–51% to –25%	Very similar in design to the U.S. expanded-mesh BRD, consistently excludes fish bycatch, no clogging occurs, manufacture is labor intensive, well respected design by commercial fishermen
Commercial vessel, research observer	Neil Olsen BRD[6]	Tropical, coastal	14	–6%	–21% to +13%	–20%	–45% to +27%	Has been used commercially in tropical, inter-reef areas with no marked prawn losses; reductions in bycatch were less consistent; ability to exclude animals affected by visibility conditions, i.e. light, water clarity
Commercial vessel, research observer	Bigeye BRD	Tropical, coastal	19	+3%	–15% to +24%	0%	–16% to +19%	Excludes swimming animals, i.e. sharks, stingrays, and some fish species; ability to exclude animals affected by visibility conditions, i.e. light, water clarity, and possibly trawl speed; used commercially by a proportion of the banana trawl fleet

[1] Prawn trawling in the Queensland east coast trawl fishery is predominantly a night time activity. Fishery conditions will include night time trawling unless specifically stated as daytime.

[2] Range based on 95% confidence interval of mean difference between standard and modified trawl nets. A – indicates the modified nets had reduced catch relative to the standard net, and a + indicates the modified nets had an increased catch relative to the standard net.

[3] Robins-Troeger, 1994

[4] Robins et al., 1995

[5] Robins and McGilvray, 1998

[6] Queensland Department of Primary Industries, unpubl. data on file at the Southern Fisheries Center, P.O. Box 76, Deception Bay, Qld 4508, Aust.

sion project was initiated in mid 1996 (Robins, 1997). The aim of the project was to inform fishermen of the available technology to reduce fishery bycatch, how this technology could make trawling more efficient and "environmentally acceptable," and to provide a low-cost means of evaluating bycatch reduction technology in commercial prawn fisheries of northern Australia. The extension program offered overseas and locally developed TED's and BRD's on loan to trawl operators for evaluation under commercial conditions. Previous experience suggested that TED's and BRD's needed to suit the different trawling conditions of the Queensland east coast trawl fishery (i.e. estuarine, coastal, oceanic, interreef, deepwater, daytime, nightime). Research staff custom-made TED's and BRD's to suit individual fishermen and, where possible, assisted them in commercial testing of the gear at sea. Results of these commercial supervised gear trials of TED's and BRD's were variable (Table 3).

As expected, TED's were very efficient in excluding large animals such as rays, *Rhynchobatus* spp. and *Dasystis kuhluii*; sea turtles, and sharks. The effect of TED's upon catch rates of other bycatch species, such as unwanted fish and sea snakes, was more variable, as indicated in the large range of bycatch rates observed during research and commercial tests (Table 3). Significant reductions in bycatch were observed during tests of the AusTED, AusTED II, and the Seymour TED, but these were often associated with some degree of reduction in the commercial prawn catch (Table 3). The best results were observed during testing of the AusTED (subtropical coastal conditions), and the monofilament BRD, where bycatch was consistently reduced, but mean prawn catches were not reduced (Table 3). Many of the TED's tested achieved promising results, in terms of retaining prawn catches, until trawling operations moved into areas where sponges and starfish were common. These species tended to clog against the bars of the TED's, which resulted in reductions in the prawn catch (Table 3). The BRD's tested in the Queensland east coast trawl fishery were not observed to clog with sponges or starfish, as the design of the devices are very different to the physical barrier of a TED. This is one feature that makes BRD's more attractive than TED's to Queensland fishermen. Of the BRD's tested, the greatest reduction in unwanted bycatch, especially fish bycatch, occurred during daytime trawling (Table 3). Anecdotal reports from Queensland fishermen who have tested BRD's suggests that this is a common result.

Industry Solutions to Fishery Bycatch

The supervised gear tests on commercial vessels and port displays of TED's and BRD's inspired several local operators to test and develop their own designs (Fig. 2). Most are based on modifications or refinements of TED's and BRD's used in the United States of America (Watson et al., 1994). This may be because the Queensland east coast trawl fishery is more similar in fishing operations and species caught to the penaeid shrimp fisheries of the southeastern United States than to the temperate-water groundfish and pandalid shrimp fisheries of northern Europe, where square-mesh and the Nordmore[2] grid are predominantly used (Briggs, 1992; Isaksen et al., 1992).

Two Queensland designs are of note, the John Olsen Bigeye and the Wicks TED, mostly because of their widespread adoption by Queensland fishermen. The John Olsen Bigeye is basically a very large fisheye that can be sewn anywhere in the body of a trawl net (Fig. 2, 3). Bigeyes were designed to exclude unwanted fish bycatch from trawls during fishing for banana prawns. Fishing for banana prawns forms one sector of the Queensland east coast trawl fishery, and occurs mostly during the day in shallow, turbid waters adjacent to rivers, creeks, and bays. It is associated with the Queensland wet season between January and July. Prominent fish bycatch species[3] include pony fish, *Leiognathus* spp.; croaker, *Johnieops vogleri*; trevally, *Caranx para*; grunter, *Pomadasys maculatum* and *Terapon theraps*; and hairtail, *Trichiurus lepturus*.

Preliminary feedback from the fishery indicates that about 30% of the banana-prawn fleet installed and used a Bigeye BRD during the 1998 fishing season. Anecdotal reports suggest that unwanted fish bycatch was usually reduced by between 30% and 40% during daytime fishing. At night or in extremely turbid water, exclusion rates were between 10% and 15%, and were less consistent (Table 3). Fishermen also reported a reduction in the catches of sea turtles, sea snakes, sharks, and stingrays in nets fitted with the Bigeye BRD. The ready acceptance and use of this local design is due to several factors in its advantage over other BRD's:

1) It is simple and cheap to install,
2) It has no rigid parts,
3) It can be any size and can therefore allow large animals (i.e. stingrays) to escape, and
4) It can be sewn into any part of the trawl forward of the codend, unlike most other BRD's.

The Wicks TED is basically a flat, rectangular grid, being curved on one side (Fig. 2). It was designed primarily to exclude jellyfish from trawl nets by retired fisherman Kevin Wicks. A modification to this design that was particularly suitable for conditions in Moreton Bay (lat. 27°S, long. 153°E) was the ability to change the spacing of the deflector bars of the TED by having a dual frame system (Fig. 2). This TED is fished with 64 mm bar spacings when jellyfish are abundant, and the second grid is removed, giving a grid with 127 mm bar spacings, while fishing in areas where blue swimmer crabs are retained as marketable catch. The design also includes a gusset between the outer frame of the grid and the first deflection bar, providing a tie-off point for the escape hole. This improves the robustness of the installation of the grid, possibly preventing slipping of the meshes and subsequent changes in grid angle. TED's have been adopted by about 80% of the fleet in the particular area of Moreton Bay (Queensland, Australia), mostly because of the benefits of TED's during times of high jellyfish abundance. However, an additional benefit has been the exclusion of sea turtles (which are a frequent catch: i.e. more than 1 per 5 nights of fishing) and stingrays (i.e. more than 1 per night).

Uptake of TED's and BRD's

It has taken several years for operators within the Queensland east coast trawl fishery to embrace the concepts and technology associated with TED's and BRD's. Voluntary use of TED's has been restricted to individuals and selected areas where TED's are seen to have advantages. Legislative deadlines have provided incentive for the majority of vessels within the Queensland east coast trawl fishery to consider using TED's. BRD's for fish exclusion have been viewed much more favorably by the commercial trawling industry. Local designs were the catalyst for the uptake of BRD's by a significant portion of the Queensland east coast trawl fishery. Again, legislative deadlines for BRD's have provided incentive for the remainder of the fleet.

Conclusion

TED's and BRD's are currently the main solutions to the issue of prawn-trawl fishery bycatch in Australia. The greatest advances in adoption rates have occurred after respected individuals

[2] Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[3] Queensland Department of Primary Industries unpubl. data on file at Southern Fisheries Center, P.O. Box 76, Deception Bay, Qld. 4508, Aust.

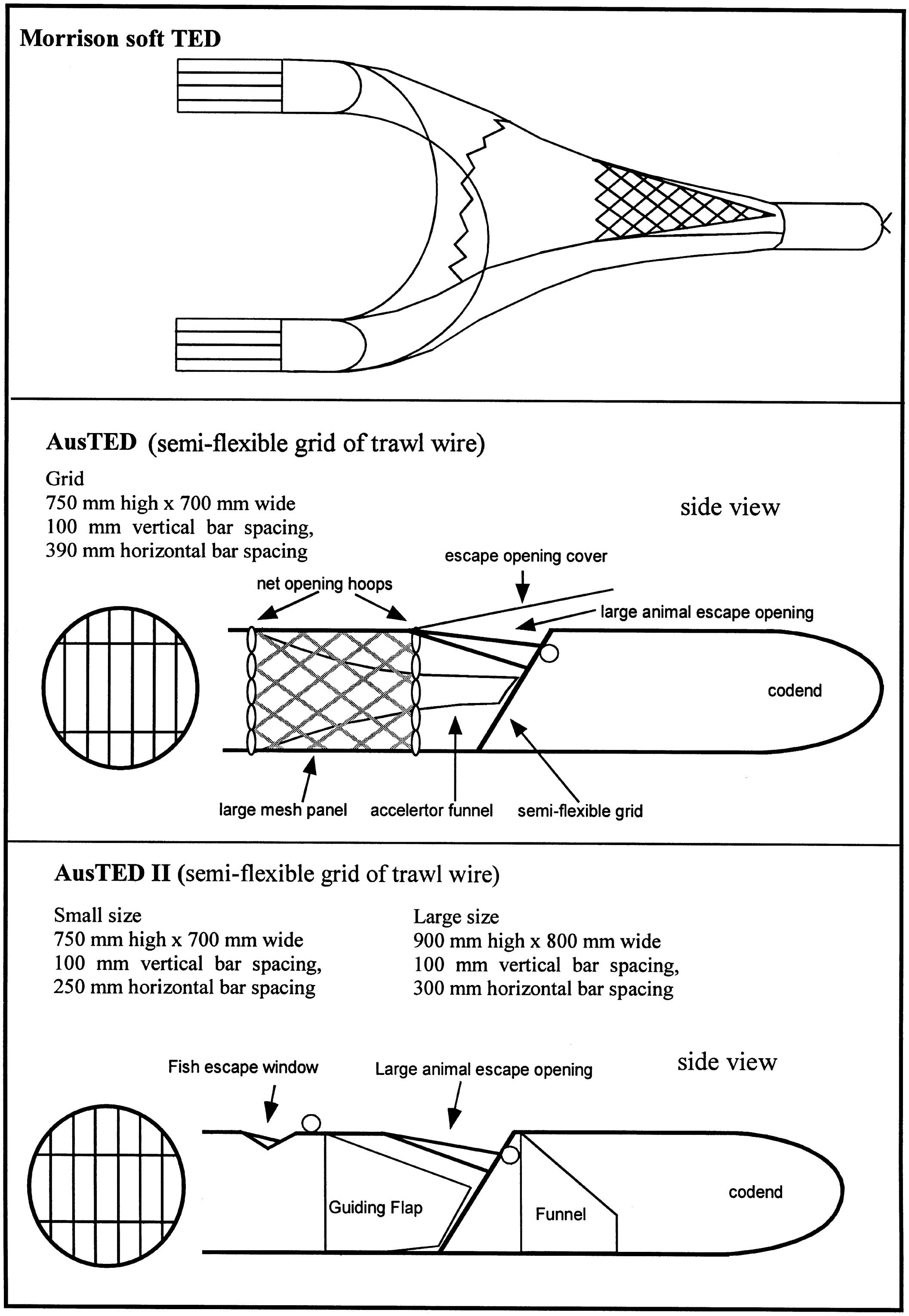

Figure 2.—TED's and BRD's designed or evaluated in the Queensland east coast trawl fishery.

within the fishing industry have developed or modified gear that reduces bycatch. The use of the new technology clearly demonstrates to their peers the advantages and efficiency with which TED's and BRD's can work when mod-

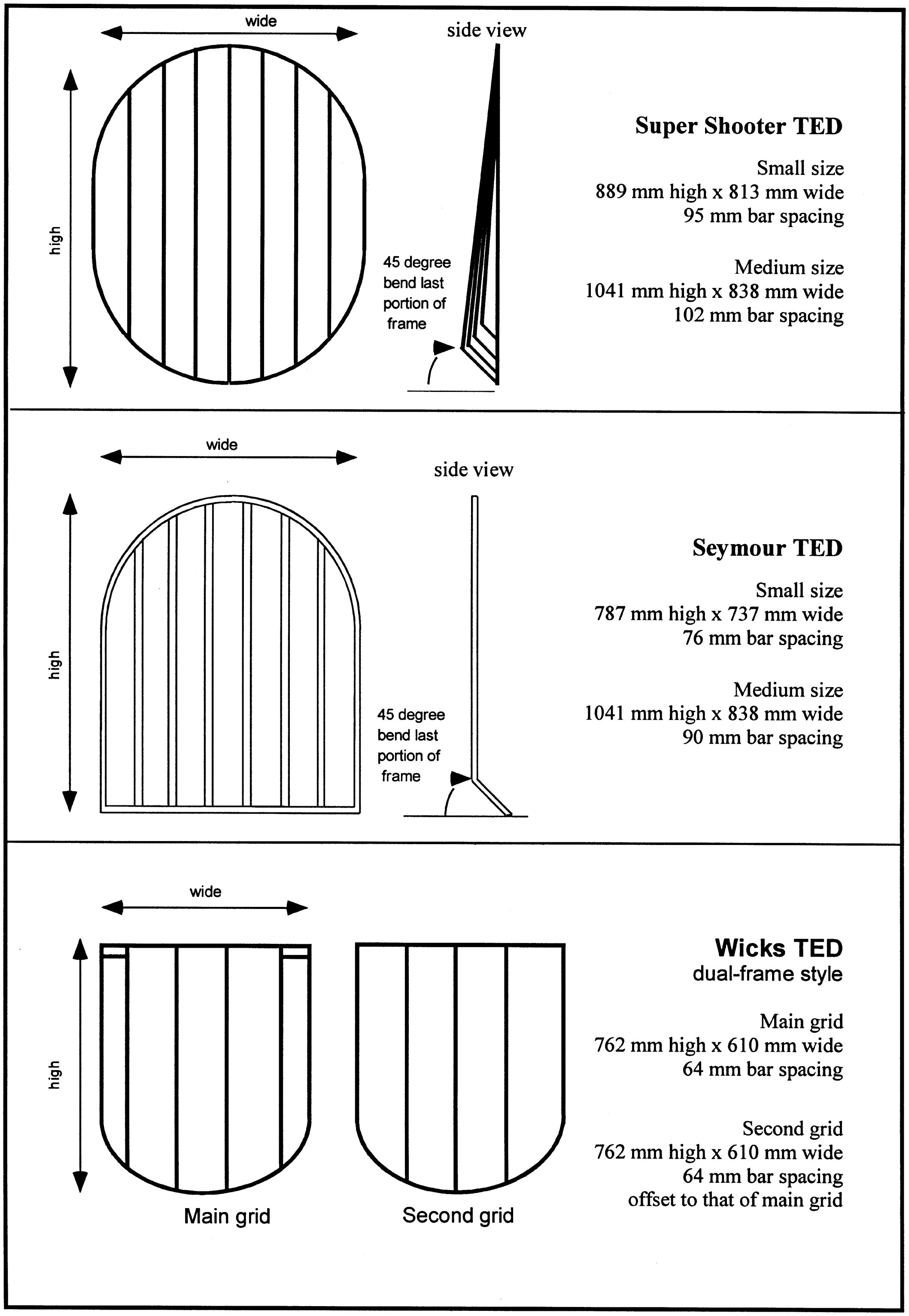

Figure 2.—Continued.

ified for local conditions. In hindsight, Australia benefited greatly from overseas experiences in the development and implementation of technology that reduces fishery bycatch (Tucker et al., 1997).

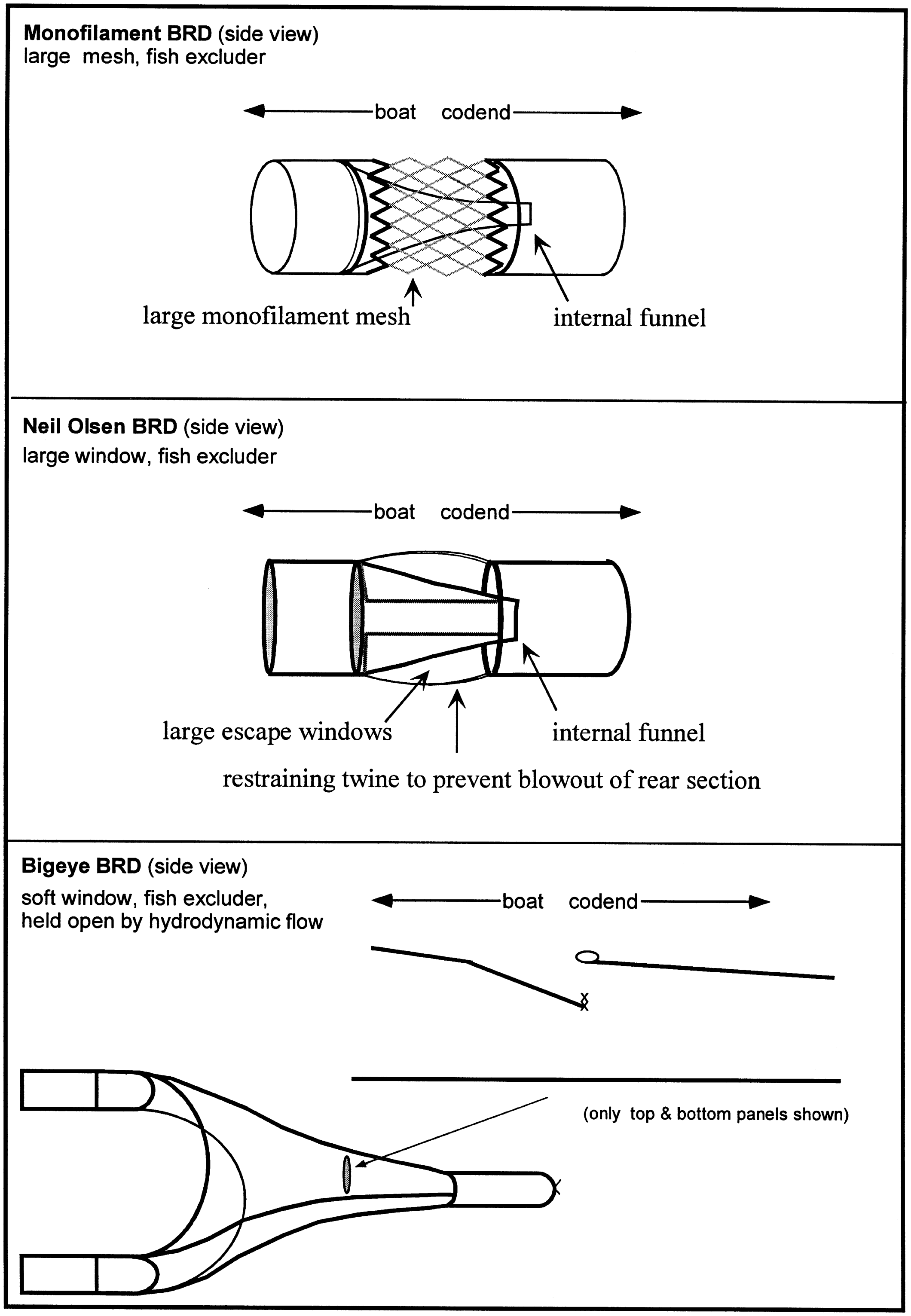

Figure 2.—Continued.

In general, we have little understanding of the potential ecosystem effects that will emanate from the use of TED's and BRD's in trawl fisheries of northern Australia. Even if monitoring of these ecosystems occurs, it will be difficult to

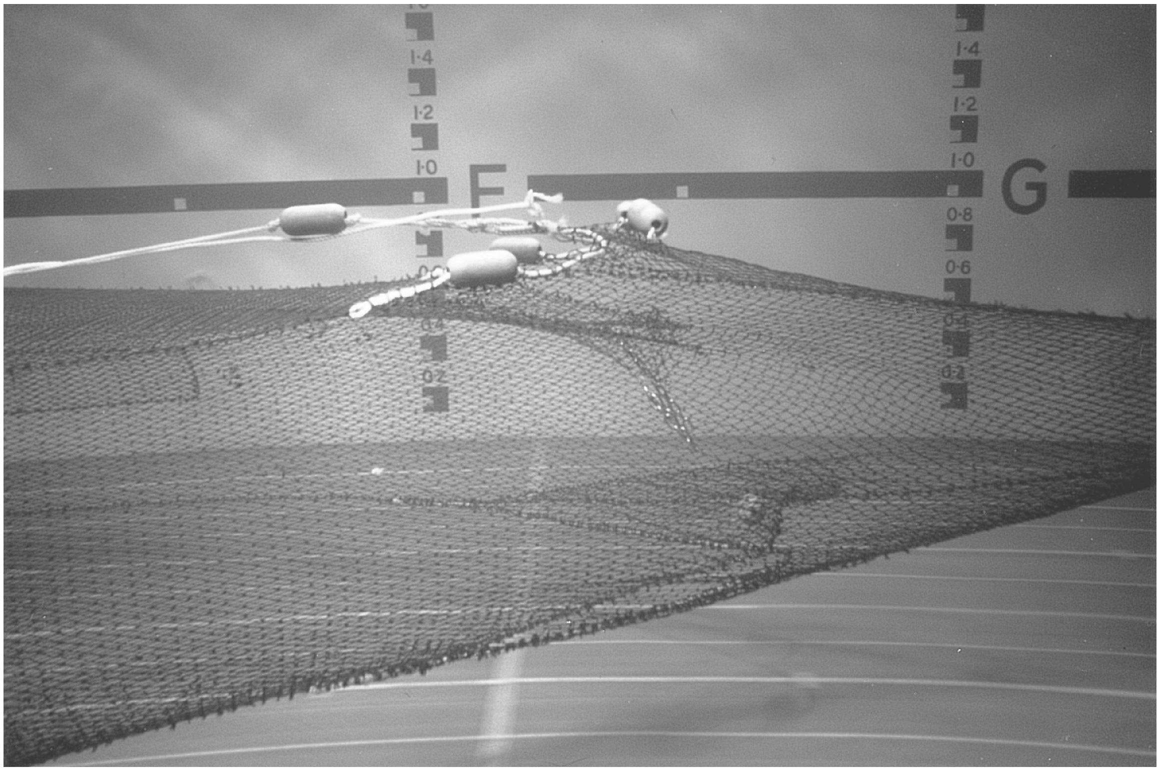

Figure 3.—Queensland try net (3.66 m headline) fitted with a John Olsen Bigeye BRD, being examined in the flume tank of the Australian Maritime College (photo by G. Day).

separate changes in the ecosystem due to the use of TED's and BRD's from the environmental variations prevalent in northern Australia.

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